STAATSBEDRIJF DER POSTERIJEN, TELEGRAFIE EN TELEFONIE

REPORT 164 MA

PROCESS FOR AN ALGOL TRANSLATOR

PART ONE:

THE TRANSLATOR

DR. NEHER LABORATORIUM

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1.0 General comment
1.1 Procedure S0 : stores word in object program on address P.
1.2 Procedure S0a: extracts from list L and conjugates.
1.3 Procedure S0c: stores word in list L on address S.
1.4 Procedure S0d: equips object programme with storing and extracting a partial result.
1.5 Procedure S0e: stores declaration list I.
1.6 Procedure S0f: looks up identifier f in list I.
1.7 Procedure S0g: shifts list L to the mid of the range P...T.
1.8 Procedure S0h: completes dynamic introduction of a block.
1.9 Procedure S0i: reserves address P of the object programme for a pass instruction.
1.10 Procedure S0k: places extract normally instruction.
1.11 Procedure S0l: contra declares a label.
1.12 Procedure S0m: stores word in list L on address So-1.
1.13 Procedure S0n: stores contra declaration and internal equivalent of an identifier.
1.14 Procedure S0p: contra declares name of function having no parameters.
1.15 Procedure S0r: inverts gression bit of instruction d.
1.16 Procedure S0s: makes contra declaration of subscripted actual parameter.
1.17 Progressive and regressive after-actions of the opening symbols.
1.18 Compound statement "Entry".
1.19 Compound statement S1: Entry for delimiters being either an operator, or a separation or closing symbol.
1.20 Compound statement S2: Pre-action of the opening symbol <u>if</u>.
1.21 Compound statement S2a: After-actions of the opening symbol <u>if</u>.
1.22 Compound statement S3 : Pre-action of the opening symbol <u>begin</u>.
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1.25 Compound statement S3c: Entry for colon.
1.26 Compound statement S4 : Entry for identifiers.
1.27 Compound statement S4a: Entry for constants.
1.28 Compound statement S5 : Pre-action of the opening symbol (.
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1.30 Compound statement S5b: Action of the delimiter lsq.
1.31 Compound statement S6 : Pre-action of the opening symbol [.
1.32 Compound statement S6a: After-actions of the opening symbol [.
1.33 Compound statement S7 : Pre-action of the opening symbol for.
1.34 Compound statement S7a: After-actions of the opening symbol for.
1.35 Compound statement S8 : Pre-action of the opening symbol go to.
1.36 Compound statement S8a: After-actions of the opening symbol go to.
1.37 Compound statement S8b: After-actions of the opening symbol switch.
1.38 Compound statement S8d: After-actions of the opening symbol procedure.
1.39 Compound statement S9 : Pre-action of the opening symbol:=.
1.40 Compound statement S9a: After-actions of the opening symbol:=.

ALGOL Translator

begin comment

Restrictions in action:

1 In any block head within a text to be translated, the declarations of simple varables and arrays are supposed to precede those of procedures and switches.

2 The bounds of own arrays are supposed to be integral constants.

3 The controlled variable of a for statement may not be a subscripted variable.

Notations:

1 Above each labeled line, all references to the label are gathered, represented by "approximate" labels.

2 Within the programme, many constants are written in a semi-binary notation, in which powers of 2 occur as factors and terms.
Crosses x on the right-hand side of the pages mark the lines, in which such non-variable expressions appear which, of course, should better be replaced in the text by their values.

3 Other constants, listed in table 1E, are conveniently referred to by names which, in praxis, are to be replaced in the text by the appropriate values. Crosses + on the right-hand side of the pages mark the lines concerred.

Composition:

The translator, a block, contains procedure wrong, the procedures of the S0-series,
the switches sw and SW, and the compounds S1, S2, S2a, S3, S3a, S3b, S3c,S4,S4a,S5,S5a,S5b,S6,S6a,S7,S7a,S8,S8a,S8b,S8d,S9,S9a, input and input1.

input, depending on the kind of string taken from the tape, goes to either S4L1 (for an identifier), or to S4aL1 (for an unsigned number), or to one of the labels mentioned in tables 1A and 1B. It assigns the value of the string to variable f of table 4A, which is, however, not necessary when the string is a delimiter

: : = ([begin for go to if lsq .

When f is a number, input assigns the value

0 000000t01 0...0 to variable g. The bit t indicates the representation of the number f.

input1 (cf. S5b).

Non-ALGOL features:

1 The translator considers boolean type to be the same as integer type. Thus variables declared boolean may assume integral values. Internally, true and false are represented by 0 and -1 respectively. Then the significance of operator or can be extended as follows:

2 When applied to integers p and q, p or q denotes the logical product of p and q which, of course, might also be obtained by a procedure logical product (par1, par2).

3 The ZEBRA, for which this translator has been developed, is a binary machine with 8192 locations in its store, each of which containing 33 bits b_0, b_1 ... b_{32}.
b_0 is the sign digit: b_0=0 → pos., 1 → neg.
Then x < 0 is a short notation for logical product $(x, 2^{32}) \neq 0$;

```
                                    comment
own integer array st [P0: Q0];      In this space, object programmes are built up, and it  +
                                    also contains the lists I and L needed in translation
                                    time (cf. variables P, T, S of table 4A);

integer a, b, c, d, e, f, g,        cf. table 4A;
D, mark, P, q, R, S, S accent,
S0, T, T1, T2, u, v;

procedure wrong;                    This hardware programme stops and prints address, from
                                    which it has been invoked. That address corresponds to
                                    the occurred kind of misery listed in table 5 as a
                                    function of a variable assuming labels as values;
```

```
                                                    comment
procedure SO(F);                    stores word in object programme on address P;
begin
st[P] : = F; P : = P + 1;
if P>SO-2      then SOg;            for shifting list L away from object programme
end SO;
```

```
                                        comment
procedure S0a;                          extracts from list L and conjugates;
begin
c : = st[S - 3];
d : = st[S - 2];
e : = st[S - 1];
a : = 480 or d; b : = 480 or f; 480 is = 511 - 31, thus b is = 32 x rank of
                                delimiter f (cf. tables 1 A and B)
end S0a;
```

```
                                        comment
procedure SOc(F);                       stores word in list L on address S;
begin
st[S] : = F; S : = S + 2 ;
if S + 1 > T then SOg;                  for shifting list L away from I
end SOc;
```

```
                                    comment
procedure SOd;                      equips object programme with storing and extracting a
                                    partial result;
begin
st[Saccent - 1] : =
2↑23 × 3 + 2↑26 × 63;                                                              ×
SO(partres)                                                                        +
end SOd;
```

```
                                        comment
procedure SOe(F)                        stores declaration in list I;
begin
st[T - 1]: = e;                         is internal equivalent of identifier F;
st[T]: = F; T: = T - 2;
if S + 1 > T then SOg;                  for shifting list L away from I (cf.SOc)
end SOe;
```

```
                                        comment
    procedure SOf;                      looks up identifier f in list I. on addresses
                                        T1 + 2, T1 + 4, ... T2.
                                        If f is found, then  c : = lowest address where f
                                        occurs, and d : = corresponding internal equivalent,
                                        which is positive.
                                        Otherwise d : = -1.
                                        If f is found to be a simple variable or formal
                                        parameter, then e : = d.
                                        Otherwise e : = 2^32 + f, which is the contra-
                                        identifier of f, being negative.
                                        If f is found to be an array identifier, then
                                        g : = the ar1 instruction which is the internal
                                        equivalent of the factor identifier, being neg.(cf.S6L8) and
                                        u : = d, which is used on S6L 17
    begin                               Otherwise g : = 0;
    g : = 0; c : = T1;
SOfL1: if T2 = c then go to             Then identifier has not been found;
    SOfL3;
    c : = c + 2;
    if st[c] ≠ f then go to             for extracting the next identifier;
    SOfL1;
    d : = e : = st[c - 1];              which is the internal equivalent of identifier f;
    if 2 × d > 0 then
    begin
    if 4 × d > 0 then go to             for label, switch- and procedure identifier;
    SOfL4;
    e : = c - 1;                        f is array identifier;
```

```
                                                    comment
SOfL2 : e : = e - 2; g : = st[e];
        if g > 0 then go to SOfL2;  Then ar1 instruction is not yet found;
        u : = d; go to SOfL4;
SOfL3 : d : = -1;
SOfL4 : e : = f + 2↑32                                                    ×
        end                         This compound statement is omitted in the case of a
                                    formal parameter or simple variable
        end SOf;
```

```
                                        comment
      procedure SOg;                    shifts list L to the mid of the range P ... T;
      begin
      a : = (P + T - S - SO) ÷ 2;       The distance from the mid of SO...S to that of
                                        P...T is = a + l with either l = 0, or ½, or -½;
      Saccent : = Saccent + a;
      S : = S + a;
      SO : = SO + a;
      if P + 2 > SO then
SOgL1: wrong;                           Then translator is short of working space.
                                        Otherwise P + 2 is ≦ SO
                                        and, because of abs(l) ≦ ½, also S + 1 ≦ T
                                        as required in procedures SO, SOc, SOe, and SOm;
      if a > 0 then
      for b : = S step -1 until SO
      do st[b]: = st[b - a]
      else
      for b : = SO step 1 until S
      do st[b] : = st[b - a]
      end SOg;
```

```
                                        comment
procedure S0h;                          is invoked after reading the first array identifier
                                        of a list being not own (cf.S4L17), and also, when
                                        translation of a statement is beginning (cf. S2, S3,
                                        S5, S6, S7, S8, S9, S3cL2  and S3bL1). Bridging pass
                                        instructions are inserted in the dynamic introduction
                                        of a block on addresses previously reserved by
                                        procedure S0i, and the introduction is also completed
                                        by putting the instruction retain to its end.
                                        The procedure assigns the same values to variables c,
                                        d and e as does procedure S0a;
begin
a : = st[S - 7];
c : = st[S - 3];  d : = st[S - 2];
e : = st[S - 1];
if d = 322 and c ≠ 0 and a ≧ 0
then
begin                                   This only happens, when translation of a block head is
                                        still running;

if a > 0 then st[a] : =
P + 2↑23 + 2↑26 × 121;                  Then pass instruction (cf. table 1D) is inserted on  x
                                        address a;

if D < 0 then a : = D else a : = 0;
st[S - 7] : = a;
if a < 0 then
begin                                   Dynamic introduction of block is completed.
                                        q is smallest address reserved for simple variable
                                        which is local to block;

q : = q - 1 ;
```

```
S0(retain);
end
end S0h
```

comment
cf. table 1 E

Thus, when st[S - 2]= 322 which is the value of begin and st[S - 3]≠ 0, (cf. S3 and S3a), then st [S - 7] can be the address where to insert a pass instr. in dynamic introduction of block at next call of procedure S0h (cf. S0i), or 0 when no pass instr. is to be inserted, or negative, when introduction is ready;

```
                                    comment
procedure SOi;                      is invoked on S4L10, S4L14, S4L24, S4L37.
                                    Unless there has already been reserved an address, it
                                    reserves address P of the object programme for a pass
                                    instruction, which is to be inserted later by
                                    procedure SOh;

if st[S - 7] = 0 then
begin
st[S - 7] : = P;
SO(0) ;                             A preliminary zero is inserted;
end
end SOi;
```

```
                                        comment
procedure SOk;                          equips object programme with filling the
                                        accumulator, which is required whenever a computation
                                        is beginning in the object programme. For const. 98
                                        cf. table 1C;

if g = 0 then
begin                                   e, if > 0, is the internal equivalent of either a
                                        simple variable or formal parameter. If < 0, e is the
                                        contra-identifier of a function name. e = 0 occurs only
                                        at a call from S1L10. Then nothing is added to the object
                                        programme;

if e ≠ 0 then
begin
if e > 0 then SO(e + 2↑26 × 98)                                                          ×
else SOp
end if e > 0;
end if g = 0
else
begin                                   Representation of constant e is indicated by bit t of g =
                                        0 000000t01 0...0;                               ×

SO (g + 2↑26 × 98);
SO(e);                                  Thus, in the object programme, constant e is subsequent
                                        to the extract normally instruction concerned;

end else
end SOk;
```

```
                                        comment
    procedure SO1;                      contra-declares a label, which is either identifier
                                        st[S] or, when g ≠ 0, the constant e.
                                        For 127 = 0 001111111  cf. table 2A;
    if g = 0 then SOn(2↑23 × 127)                                                    ×
    else
    if e < 0 or  2↑24 ≦ e then                                                       ×
SO1L1: wrong;                           cf. table 5
    else
    begin
    a : = e + 2↑24 × 63 + 2↑32;         e + 2↑24 × 63 is the identifier form of a    ×
                                        constant label e;
    e : = P + 2↑23 × 127;
    SOe(a);
    SO(0)
    end SO1;
```

```
                                        comment
procedure SOm(F);                       stores word in list L on address SO - 1;
begin
SO : = SO - 1;  st[SO] : = F;
if  P + 2 > SO then SOg;                compare procedure SO
end SOm;
```

```
                                        comment
procedure SOn(F);                       stores contra-declaration of identifier st [S]
                                        (cf. S4L23) in list I, with P + F as internal equivalent;
begin
e : = P + F;
SOe (st[S] + 2↑32);                                                              x
SO(0);                                  Thus a preliminary zero is stored in the place of
                                        an instruction which is inserted later
end SOn;
```

```
                                    comment
procedure SOp;                      contra-declares name of function having no parameters;
begin
a : = e;                            which is the contra-identifier of the function name;
e : = P + 2↑23 × 31;                                                                      ×
SOe(a);
SO(0)
end SOp;
```

```
                                        comment
procedure SOr;                          inverts gression bit of instruction d;
begin
g : = d or 2↑26;                                                          ×
if g = 0 then
begin
a : = d or 2↑26 × 126 ;                                                   ×
if a = 2↑26 × 64 or a = 2↑26 × 68                                         × ×
or a = 2↑26 × 70 or a = 2↑26 × 74
or a = 2↑26 × 80 or a = 2↑26 × 82
or a = 2↑26 × 88
then g : = - 2↑26                                                        ×
end                                     Then operator (cf. table 1A) is not commutative.
                                        When the operator is commutative, the bit d6 = 0
                                        is not replaced by 1;

d : = d - g
end SOr;
```

```
                                    comment
procedure SOs;                      This procedure makes a contra-declaration of
                                    identifier st[S] according to the value
                                    p = 0 011111111
                                    listed in table 2A together with an explanation.
                                    The procedure is invoked only on S2aL19 and S5aL27
                                    and S2aL19;

begin
a : = st[P];
e : = 2↑23;                                                              ×
if a ≠ 0 then e : = e or a;         Then e = 0 indicates that a is an ar2 instruction
                                    (cf. S6aL61) referring to a formal parameter;

if e = 0 then a : =
a + 2↑23 + 2↑26 × (108-125);        Cf. VERIFY and ar2 in table 1D;                ×
SO(a);                              Thus either a VERIFY instruction is stored, or an
                                    ar2 instruction or 0 is restored;
SOn(2↑23 × 255 - 1);                Then P is again increased, and a zero is stored ×
                                    on address P - 1, while the contra-declaration
                                    made refers to the address P - 2

end SOs
```

```
                                        comment
                                        Progressive after-actions of opening symbols
                                        (cf. table 1 B).
                                        S1L6;
switch sw : =
S5aL1, S6aL1, S3bL1, S9aL1, S7aL1,
S8aL2, S2aL1, S8dL0, S8bL2;

                                        Regressive after-actions of opening symbols.
                                        S1L21;
switch SW : =
S5aL3, S6aL5, S3bL2, S9aL2, S7aL2,
S8aL1, S2aL13, S8dL1, S8bL1;

                                        The entries correspond to the after-actions of
                                        ( [ begin : = for go to if procedure switch;
```

```
                                        comment
    begin                               Compound statement entry.
                                        The constants
                                        L0, P0, Q0, and Q00 of tabel 1E
                                        are the initial values of the address variables.
entry: P : = P0 + 1;                    When, on S3bL8, the translation finishes, the  + +
                                        first word of the object programme is inserted on
                                        address P0;

       q : = Q0; T 1 = T1: = Q00-2xh;
       T2 : = Q00;
       S0 : = L0;
       S : = 1 + S0;
       st[S0 - 1] : = R : = 0;
       go to S6aL11;                    Then Saccent : = 8191,
                                        st[S0]: = g : = mark : = 0.
                                        As the opening symbol begin occurs in front
                                        of any text, input goes to compound S3.
                                        Procedure S0h cannot do any harm, for
                                        st[S - 2] = 0 differs from the internal value 322
                                        of begin.

    end entry;
```

```
                                    comment
    begin                           Compound statement S1.
                                    After reading a delimiter  f  which is either an
                                    operator (table 1A) or a separation or closing
                                    symbol (table 1B),
                                    procedure input goes to here;
S1L1: SOa;                          Then c = st[S - 3], d = st[S - 2], e = st[S - 1],
                                    a = 32 × rank r_d of delimiter d,
                                    b = 32 × rank r_f of delimiter f;
S1L2: if Saccent = S then go to S1L4;  cf. S3aL4 and S5aL5. Then the identifier or constant
                                    preceding delimiter  f  in the text need not be
                                    examined;
      if g < 0 then g : = 0;        Then identifier st[S] = e - 2^32 represents an array
                                    (cf. S4L22). As this significance of the identifier is
                                    nonsens here, it must be non-local, and another
                                    local declaration of the identifier may be expected
                                    later.
                                    Only exception: identifier is actual parameter,
                                    representing array. Then g : = 0 does no harm;
      if e = 0 and g = 0 then go to Then delimiter  f  is preceded in the text by the
      S1L3;                         0-identifier (there is no identifier and no constant);
      if f ≠ 32 × 5 + 2↑26 × 97
      then go to S1L4;
S1L2a: wrong;                       Operator not is preceded by an identifier or constant.
                                    S1L2;
S1L3 : if a < 128 then
S1L3a: wrong;                       Then an identifier or constant has been omitted behind
                                    the arithmetic operator d;
      if f = 32 × 3 + 2↑26 × 72     for skipping +  in a = + b etc.;
      then go to input;
```

```
                                        comment
     if d = 322 then go to S1L21;       for a dummy statement. Then the after-action of  d
                                        with  f = semi-colon or end is considered to be regressive;
     if f = 32 × 5 + 2↑26 × 97          for operator not;
     then go to S1L4;
     if f ≠ 32 × 3 + 2↑26 × 74 then
S1L3: wrong;                            Then an identifier or constant has been omitted;
     f : = 32 × 3 + 2↑26 × 96;          In a = - b etc.  -  is treated this way.
                                        S1L2;
S1L4: if b < a then go to S1L26;        Then reading continues and d is a regressive operator or
                                        opening symbol.
                                        Otherwise reading is interrupted: ;
S1L5: if Saccent = S then go to S1L21;  Then d is either a regressive operator, or an opening
                                        symbol which is regressive with respect to the after-action
                                        with  f  (cf. S5aL5 and S3aL4).
                                        In general, however, an operator or opening symbol  d
                                        which is translated first after interrupting the
                                        reading, is progressive: ;
S1L6: if a = 320 then go to sw [d-319]; for progressive after-actions of opening symbols;
S1L7: if Saccent + 2 < S then S0d;      Then object programme must be provided with storing and
                                        extracting a partial result;
S1L8: a : = d or 2↑23 × 5;              Then a is either = 0 or
                                        a = 0 000000t01 0...0  and c a programme const. whose
                                        representation is indicated by the bit  t. For  g  and  e
                                        it is analogous(cf. S1L26 and S1L29);
S1L9: d : = d - a + g;                  which is thus associated to e instead of c;
S1L10:if Saccent + 2 = S then go to     Otherwise object programme must be equipped with
     S1L11;                             filling the accumulator:;
     g : = a;
     a : = e; e : = c; c : = a;         c and e interchange their values;
```

```
                                        comment
      SOk;  e : = c;                    Thus previous value of e is restored.
                                        S1L10, S1L25;
S1L11: if d or 2↑23 ≠ 0 then go to      Then instruction d is ready and e is a programme
      S1L15;                            constant to be used by instr. d;                    ×
S1L12: if e > 0 then go to S1L14;       Then e is the internal equivalent of either a simple
                                        variable or formal parameter.
                                        Otherwise e - 2^32 is an identifier (cf. S4L22) which,
                                        in this position, can only be the name of a function
                                        having no parameters: ;
      if d ≠ 32 × 3 + 2↑26 × 96 and     Otherwise d is an operator not or - such as         ×
      d ≠ 32 × 5 + 2↑26 × 97            does not, in operation time, require to store
      then go to S1L13;                 a previous partial result: ;                        ×
      SOp;                              Compare S1L13;
      go to S1L22;                      S1L12;
S1L13: SO (partres);                    for storing previous partial result;
      SOp;                              Thus a contra-declaration of identifier c - 2^32
                                        is made according to p = 0 000011111 which constant
                                        is listed in table 2A together with an explanation;
      e : = 2↑23 × 507;                 For, in operation time, instruction d must          ×
                                        extract a partial result;
      SOr;                              Thus the gression bit d6 is inverted. When, for
                                        example, function - p × q + ... is translated, then
                                        operator - is regressive according to the general
                                        rule. Thus p × q is translated first. Before, in
                                        operation time, function may be invoked, the object
                                        programme must at first store the partial result accu
                                        which is p × q. Therefore the minus instruction is to
                                        be translated in the form
                                        accu : = accu - (partial result)
                                        which is progressive instead of regressive.
```

```
                                        comment
                                        S1L12;
S1L14: e : = e - 2↑26 × 63 +
       (d or 2↑26 × 127);                                          ×
       go to S1L16;                     S1L11;
S1L15: SO(d);                           S1L14, S1L22, S1L23;
S1L16: SO(e);                           Thus instruction or programme constant is stored
                                        in the object programme.
                                        S3bL14, S7aL18, S8aL3, S9aL2;
S1L17: Saccent : = S : = S - 2;         Operator st[S] has been translated and will be
                                        overwritten now;
S1L18: SOa;                             cf. S1L1;
S1L19: if b < a then go to S3L5;        Then translator again proceeds to reading.
                                        Otherwise translation continues (cf.S1L4).
                                        S1L5, S1L3;
S1L21; if a = 320 then go to            for regressive after-actions of opening symbols
       SW[d - 319];                     (cf. S1L6).
                                        S1L12;
S1L22: if d ≠ 32 × 5 + 2↑26 × 97
       then go to S1L23;                                           ×
       e : = take inversion;            That code instruction of table 1E is the regressive
                                        version, and extract inversion of table 1C is the
                                        progressive version of operator not;
       go to S1L16;                     S1L22;
S1L23: if d ≠ 32 × 3 + 2↑26 × 96        That code instruction of table 1E is the regressive  ×
       then go to S1L24;                version, and extract complement of table 1C which
       e : = take complement;           has been introduced at the end of S1L3 is the
                                        progressive version of operator -, when - is preceded
                                        by the 0-identifier;
       go to S1L16;                     S1L23;
```

```
S1L24: SOr;

       e : = c;

S1L25: go to S1L11;
S1L26: SOc (f + g);

S1L27: mark : = 0;

S1L28: st [S - 1] : = 0;

S1L29: g : = 0;
       go to input;

       end S1;
```

comment

That procedure sets the gression bit d_6 which is still = 0, to 1, for operator d is regressive;
If that is a programme constant, the indication of its representation is already recorded in d;
S1L4;
with either g = 0, or g = $\overline{0\ 000000t01\ 0...0}$, the bit t indicating the representation of e which is a programme constant (cf. S1L29).
if, at the next action of this compound S1, operator st [S - 2] just listed in L is found to be progressive, the g-part is removed from it and replaced by the next value of g, on S1L9.
S3L5, S5aL6, S6aL11;
cf. table 4C.
S3aL4, S3cL6, S5L9, S6aL31, S6aL61, S8L2, S8dL8, S9L4;
If the translator proceeds to S4L23 or S4aL2, this 0 is replaced by something else.
S4L21;
After reading a constant, procedure input goes to compound S4a with g = $\overline{0\ 000000t01\ 0...0}$ in which bit t indicates the representation of the constant f read.
On S4L22, occasionally an ar1 instruction is assigned to variable g as value;

```
      begin

S2L1: f : = 326
      SOh;
S2L2: SOc(mark);
      go to S3L3;

      end S2;
```

comment
Compound statement S2.
Pre-action of the opening symbol if;
Cf. if in table 1B;
Cf.S3L2;

Then, for translating an if-expression, there is listed in L:
st[S - 4] = mark (cf. table 4C),
st[S - 3] = 0,
from 1st after-action: minus address P'
where to store a test instruction,
from 2nd after-action: plus address P"
where to store a pass instruction.
st [S - 2] = value 326 of if,
st [S - 1] = 0.
Signal mark is set to 0. The listed value, st [S - 4], is re-introduced on the 1st and 2nd after-actions of if;

```
                                    comment
    begin                           Compound statement S2a.
                                    After-actions of the opening symbol if.
                                    Delimiter f is either then or else or the
                                    closing symbol of a conditional expression or
                                    - statement E. On S1L1, the value 0 or -P' or
                                    +P", mentioned in compound S2, has already been
                                    assigned to variable c.
                                    Progressive:
                                    The expression, preceding delimiter f, is a
                                    single identifier or constant i
                                    S1L6;
S2aL1: d : = st [S - 4];            being the value of mark retained by compound
                                    statement S2;
S2aL2: if c × d ≠ 0 then go to S2aL4;  Then the 2nd or 3rd after-action of if is
                                    beginning, f being else or the closing symbol,
                                    and, in addition, d is = 1 or 2.
                                    Then i may be a label.
                                    Otherwise i is no label: ;
S2aL3: SOk;                         Thus object programme is equipped with filling
                                    the phantom accumulator;
       go to S2aL20;                S2aL2;
S2aL4: if d = 2 then go to S2aL17;  Then i is a label (or a formal parameter that
                                    may only represent a label), and E is a
                                    designational expression.
                                    Otherwise expression E is an actual parameter;
S2aL5: if g ≠ 0 then go to S2aL11;  Then i is the constant e.
                                    Otherwise i is an identifier : ;
S2aL6: if e < 0 then go to S2aL9;   Then i = e - 2^32 is found to be no simple
                                    variable and no formal parameter (cf.S4L22).
```

```
                                        comment
                                        Identifier  i  is found to be a simple variable
                                        or formal parameter with the internal equivalent e:;
S2aL7: if e - 2↑23 × 505 > 0            Then  i  is a simple variable, and an extract-normally
       then go to S2aL18;               instruction is added to the object programme.
                                        Otherwise  i  is a formal parameter:;
S2aL8: g : = e + 2↑23 + 2↑26×(110-63);  which is a verify instruction (cf. table 1D).      ×
                                        In operation time, the bit g9 = 1 of instruction g
                                        makes the test on S10L13 fail, and the interpreter
                                        proceeds to S10L140. There the instruction X whose
                                        formal parameter represents the actual parameter in
                                        which expression E is contained, is examined: If X is
                                        no jump instruction, then the formal parameter  i  to
                                        which the verify instruction refers, cannot represent
                                        a label so that the verify instruction is to be
                                        interpreted as the extract normally instruction referring
                                        to  i.
                                        S2aL6;
S2aL9: S0(g);                           S2aL18;
S2aL10:g : = st [S] + 2↑32;             being the contra-identifier of i                   ×
                                        (cf. S4L23);
       e : = P + 2↑23 × 511 - 1;                                                           ×
       go to S2aL12;                    The contra-declaration  g, e  to be stored now is made
                                        according to p = 0 111111111 which constant is listed in
                                        table 2A together with an explanation. It refers to the
                                        address x = P - 1, where the object programme contains
                                        either the mentioned verify  or extract normally
                                        instruction or 0.
                                        S2aL5;
```

```
                                        comment
S2aL11: SOk;                            Then st[P - 2] is the extract normally instr.
                                        which, in operation time, extracts the programme
                                        constant st [P - 1] = i;
        if e < 0 or 2↑24  ≤ e           Then constant  i  is not suitable for being a label.
        then go to S2aL20;              Constant  i  may occur as a label:;                  ×
        g : = e + 2↑24×63 + 2↑32;       which is the contra-identifier of a constant label i;
        e : = P + 2↑31 × 3 - 2;         The contra-declaration g, e  to be stored now is     ×
                                        made according to p = 1 100000000  which constant is
                                        listed in table 2A together with an explanation. It
                                        refers to the address x = P - 2, where the object
                                        programme contains the extract normally instruction. The
                                        internal equivalent  e  is negative.
                                        S2aL10;
S2aL12: SOe(g);                         thus the contra-declaration is stored now;
        go to S2aL20;                   Regressive:
                                        The expression I preceding delimiter  f  is non-trivial
                                        (no identifier and no constant).
                                        S1L21;
S2aL13: d : = st[S - 4];                cf. S2aL1;
S2aL14: if c × d = 0 then go to         Then expression I cannot be a switch designator
        S2aL20;                         (cf.S2aL2) and has already been translated.
                                        Otherwise I = i [E] is either a subcripted variable
                                        or a switch designator. The subcript E has been
                                        translated in compound S6a;
S2aL15: P : = P - 1;                    Then st[P] is either the ar2 instruction referring to
                                        i, in which case  i  has been found to be either an
                                        array identifier or a formal parameter, or 0
                                        (cf. S6aL61);
```

```
                                        comment
S2aL16: if d = 1 then go to             Then i [E] is contained in an actual parameter.
        S2aL19;                         i [E] is a switch designator thus  i  a  switch
                                        identifier:
                                        S2aL4;
S2aL17: SOl;                            Label or switch identifier is contra-declared;
        go to S2aL20;                   S2aL7;
S2aL18: SOk;
        go to S2aL10;                   S2aL16;
S2aL19: SOs;                            S2aL3, S2aL11, S2aL12, S2aL14, S2aL17;
S2aL20: mark : = d;                     At the after-actions with f = then or else signal
                                        mark is restored to the value retained by compound S2;
S2aL21: e : = P;
S2aL22: if c < 0 then go to S2aL28;     for the 2nd after-action;
S2aL23: if c ≠ 0 then go to S2aL31;     for the 3rd after-action.
                                        1st after-action:;
S2aL24: e : = - e;                      S2aL30;
S2aL25: st[S - 3] : = e;
S2aL26: SO(0);                          At the next after-action, this 0 is replaced by a
                                        test  or pass instruction;
S2aL27: go to S1L28;                    S2aL22;
S2aL28: if f ≠ 326 then e := e - 1;     Cf. else in table 1B;
S2aL29: st[-c]: =e+1+2↑23+2↑26x111;      Cf.test in table 1D;
S2aL30: if f ≠ 326 then go to S2aL32;   Then the separation symbol else is not present;
        go to S2aL25;                   else is present.
                                        S2aL23;
S2aL31: st[c]:= e+2↑23+2↑26x121;        Cf.pass in table 1D.
                                         S2aL30;
S2aL32: S : = S - 2;                    Thus, at the last after-action of if, mark is set to 0
        go to S8aL3
        end S2a;
```

```
S3L1: f  := 322;
      D := 2↑23 × 1023
S3L2: SOh;

S3L3: st[S - 1]: = 0;
S3L4: Saccent : = 8191;
S3L5: SOc(f);
      go to S1L27;

      end S3;
```

comment

Compound statement s3.
Pre-action of the opening symbol begin;
Cf. begin in table 1B;
Cf. D in table 2;
Perhaps opening symbol begin immediately follows a block head. Then procedure SOh completes the dynamic introduction of the block.
S2L2, S6L9;
S7L2, S9L10;
S1L19, S5L4, S6L19;
After pre-action of opening symbol, reading continues.
For translating a compound statement there is listed in L:
st[S - 3] = 0,
st[S - 2] = value 322 of begin,
st[S - 1] = 0

```
      begin                                  comment
                                             Compound statement S3a.
                                             After reading a declarator or specificator (table 2),
                                             procedure input goes to here;
S3aL1:D : = D or f;                          Thus declaration is replaced by its logical product
                                             with f;
      if (D or 2↑28) = 0 then go to          Then  f  is a specificator or specifying declarator;   ×
      S3aL4;
S3aL2: SOa;                                  for extracting opening symbol from list L;
      if d ≠ 322 then
S3aL2a: wrong;                               Then declarator occurs in the wrong place;
S3aL3: if c ≠ 0 then go to S3aL4             Then block has already been prepared in L by a
                                             previous declarator.
                                             First declarator of a block:;
      st[S - 1] : = q;
      SOc(P);
      SO(0);
      st[S - 1] : = T;
      SOc(322);                              S3aL1, S3aL3, S3bL2, S4L30, S5L2;
S3aL4: Saccent : = 8;                        For translating a block there has been listed in L:
      go to S1L28;                           st[S - 7] = 0, which 0 may be replaced through
                                             procedure SOi by an address to inform procedure SOh,
                                             st[S - 5] = q', being the highest address occupied by
                                             a local variable,
                                             st[S - 4] = address P' where the block has its object
                                             programme beginning,
                                             st[S - 3] = T', being the highest address in the list I,
                                             occupied by any identifier declared in the block,
                                             st[S - 2] = value 322 of opening symbol begin,
                                             st[S - 1] = 0
      end S3a;
```

```
      begin                                comment
                                           Compound statement S3b
                                           After-actions of opening symbol begin
                                           Delimiter f last read is either comma or semi-colon
                                           or end.
                                           Progressive:
                                           S1L6;
S3bL1: SOh;                                A block head may be followed by a procedure statement
                                           consisting of a single procedure identifier (cf.S3L2);
       SOn(2↑23 × 31);                     A contra-declaration of the procedure identifier is   ×
                                           made according to p = 0 000011111 which constant is
                                           listed in table 2a together with an explanation.
                                           Regressive:
                                           S1L21;
S3bL2: if f ≠ 330 then go to S3bL3;        Then f is no comma (cf. table 1B);
       If D > 0 then go to S3aL4;          Then comma occurs in list of identifiers to be
                                           declared;
S3bL2a: wrong;                             Comma occurs in a block as separator of statements.
                                           S3bL2;
S3bL3: T1: = T;                            This bound is observed by procedure SOf;
S3bL4: D : = 2↑23 × 1023;                  as happens also on S3L1;                              ×
S3bL5: if f = 332 then go to S6aL11;       for reading next declaration or statement of compound
                                           statement or block, which is subsequent to semi-colon f;
       if f ≠ 322 then
S3bL5a: wrong;                             Then a declaration or statement of a compound statement
                                           or block is followed by a delimiter, differing from
                                           semi-colon and end.
                                           After-action of begin with end:
                                           On S1L1, st[S - 3], as left by either compound S3 or
                                           S3a, has been assigned to variable c;
S3bL6: if c ≠ 0 then go to S3bL9;          Then a block is closing.
                                           A compound statement is closing;
```

```
                                    comment
        e : = Q00-2×h;              which is the highest value  T  can have;                +
        if S = S0 + 3 then go to S3bL13;Then the text is a compound statement instead of
                                    a block. Labels may occur in it.
                                    S3bL14;
S3bL7:  if S > S0 + 3 then go to input; input, in this comment situation, looks for the next
                                    delimiter  f  which is equal to either semi-colon or
                                    end  or  else, then going with  f  to S1L17. Then the
                                    delimiter preceding begin in the list L, is going to
                                    after-act with f.
                                    The whole text has been read:;
S3bL8:  S0(0);                      Thus last word of object programme is 0, but may be a
                                    jump to any stop of the machine;
        st[P0] : = P;               Thus 1st word of object programme is address where      +
                                    working space begins;
S3bL8a: wrong;                      Object programme is ready!
                                    S3bL6;
S3bL9:  S : = S - 2; S0a;           Now st[S - 4] is the delimiter preceding begin in the
        S : = S - 2;                list L. For c = q' etc. cf. compound S3a;
S3bL10: st[d] : = q+R+2↑23+2↑26×127; Thus, in object programme of block, an adjust      ×
                                    instruction is the first word;
S3bL11: S0(c+R+2↑23+2↑26×119);      Thus in object programme of block, a restore instruction ×
                                    (cf.table 1D)is the last word.
                                    S8dL7;
S3bL12: q : = c;                    Thus value of q, which was present when first declarator
                                    of block was read, is restored.
                                    S3bL6;
S3bL13: a : = T;                    On S3bL3, the value of T was also assigned to T1.
                                    S3bL15, S3bL18, S3bL20, S3bL34;
S3bL14: if a ≠ e then go to S3bL15; Then the contra-identifier occurring next on the addresses
                                    a+2, a+4, ...e is looked up.
```

```
                                    comment
                                    All contra-identifiers have been considered:;
        T1 : = T : = e;             Then in the list I  t is the highest address,
                                    occupied by an identifier which is local to the
                                    translated block;
        T2 : = Q00;                 Cf. table 1E;                                    +
        if st [S - 3]<0 then go to  Then it is a block that closes,
        S3bL7;                      st[S - 3] having been made negative by procedure
                                    SOh after reading the block head.
                                    A procedure is closing:;
        f : = 332;                  Thus semi-colon  f  of compound S8d is restored;
        go to S1L17;                as ultimately happens too with a block
                                    (cf. S3bL7).
                                    S3bL14;
S3bL15: a : = a + 2;                Then st [a] is a normal (positive) identifier.
        f : = st [a] + 2↑32;        st [a] is a contra-identifier:;
        if f < 0 then go to S3bL14;
S3bL16: T2 : = e; SOf;              Then identifier  f  corresponding to contra-
                                    identifier st [a] is looked for on the addresses
                                    T+2, T+4, ...T2;
        b : = st[a - 1];            being the internal equivalent of the contra-
                                    identifier;
S3bL17: if d > 0 then go to S3bL21; Then procedure SOf has found identifier  f  on
                                    address c, d = st[c - 1] being the internal
                                    equivalent (cf. table 2) of f. Then contra-identifier
                                    st [a] can be satisfied.
                                    Identifier  f  has not been found so that the
                                    contra-identifier remains unsatisfied:;
S3bL18: e : = T2;                   Thus the value of e as it was on S3bL16, is
                                    restored.
```

```
                                                    comment
        if S > S0 + 3 then go to                    Then the translator does not yet see the end of
        S3bL19;                                     the text, thus may regard the unsatisfied contra-
                                                    identifier as to be non-local to the closing block
                                                    or procedure.
                                                    Otherwise the text, either a block or a compound
                                                    statement, is closing:;
        if b < 0 then go to S3bL14;                 Then f = 2^24 × 63 is a programme constant, that,
                                                    because of its position within an actual parameter,
                                                    was expected to be perhaps a reference to a label,
                                                    but is found now to be not;
S3bL18a: wrong;                                     Any identifier of the text has not been defined.
                                                    S3bL18;
 S3bL19: st[a - 1] : = st [e - 1];
         st[a] : = st [e];
         st[e - 1] : = b;
         st[e] : = f + 2↑32;                        Thus 2 declarations are interchanged;                  ×
         a : = a - 2;                               The non-satisfied contra-identifier is considered to
         e : = e - 2;                               be no longer local. Thus  e  is again the highest
                                                    address where a local identifier is listed in I;
 S3bL20: go to S3bL14;                              S3bL17;
 S3bL21: T1 : = c;                                  which is used on S3bL33;
 S3bL22: e : = d or (2↑23 - 1);                     being address + 2^13 × rank;                           ×
         c : = b or 8191;                           being the address where either an instruction or the
                                                    main word of a parameter key is to be inserted.
                                                    For internal equivalent b cf. table 2A;
         b : = b - c;                               Then b = 0 indicates, that the contra-declaration
                                                    refers to the key of an actual parameter that is a single
                                                    identifier.
                                                    There must be formed either  d = main word, and
```

```
                                    comment
                                    e = by-word of the key (cf. table 3) of an actual
                                    parameter that is an identifier or a constant,
                                    or d = instruction;
S3bL23: if b ≠ 0 then go to S3bL35; for a constant parameter or an instruction.
                                    Parameter is an identifier:;
S3bL24: if 2 × d < 0 then go to S3bL29; Then parameter represents either a formal parameter
                                    or a simple variable (cf. table 2);
S3bL25: if 4 × d < 0 then go to S3bL28; Then parameter represents an array;
S3bL26: if 8 × d < 0 then go to S3bL30; Then parameter represents a label or switch.
                                    Parameter represents a procedure:;
S3bL27: d : = e or (2↑23 - 2↑13);   being 2^13 x rank of procedure identifier;        ×
        e : = e + 1 - d;            being 1 + address where procedure has its object
                                    programme beginning;
        d : = d + 2↑23 × 57;
        go to S3bL31;               S3bL25;
S3bL28: e : = g - e - 2↑23 - 2↑26×126; Cf. ar1 in table 1D;
        go to S3bL31;               As procedure SOf assigned an ar1 instruction
                                    (cf. S6L8) to variable g as value, e is a
                                    difference of addresses now.
                                    S3bL24;
S3bL29: if (d or 2↑23) = 0 then     Then actual parameter represents a formal           ×
        d : = e + 2↑26 × 3;         parameter
                                    S3bL26;
S3bL30: e : = 0;                    Thus, for a parameter representing a simple variable
                                    or formal parameter or label or switch, the by-word
                                    is cleared, which is facultative.
                                    S3bL27, S3bL28;
S3bL31: st[c - 1]: = e;             Thus by-word is stored.
                                    The key main word of a parameter, representing a simple
```

```
                                    comment
                                    variable or array or label or switch i, is equal to
                                    the internal equivalent of i.
                                    S3bL47;
S3bL32: st[c] : = d;                Thus key main word or instruction is stored.
                                    S3bL42, S3bL43;
S3bL33: SOf;                        Cf. S3bL21;
        if d > 0 then
S3bL33a:wrong;                      Any identifier has been defined twice in the same
                                    block or , or in the same procedure outside the
                                    blocks contained in it;
S3bL34: T1 : = T;                   Thus the value of T1 as it was on S3bL14, is
                                    restored;
        e : = T2;                   Ditto;
        go to S3bL14;               Satisfaction of contra-identifier st[a] is ready.
                                    S3bL23;
S3bL35: d : = d - e;
        g : = e or 8191;            Then g is the address taken from the declaration.
                                    Now the kind of the object referred to by the contra-
                                    declaration (cf. table 2A) is examined. It must be in
                                    accordance with that of the object referred to by the
                                    corresponding declaration (cf. table 2);
S3bL36: if b < 0 then go to S3bL48; Then a constant occurring in an actual parameter (or
                                    being an actual parameter) is found to be used as a label
                                    too - the declaration of which having been found;
S3bL37: if 2 × b < 0 then go to S3bL43; Then st[c] is a verify or extract normally instruction
                                    or 0, occurring in the object programme of an actual
                                    parameter (cf. S2aL6);
S3bL38: if 4 × b < 0 then go to S3bL42; Then st[c] is a VERIFY or ar2 instruction or 0,
                                    occurring in the object programme of an actual
                                    parameter (cf. S2aL15);
```

```
                                                    comment
S3bL39: if 8 × b < 0 then go to S3bL45;             Then a jump instruction is to be inserted in the
                                                    object programme of a switch or go to statement,
                                                    identifier  f  having been contra-declared on S8aL2
                                                    for example.
                                                    In the object programme of a function designator or
                                                    procedure statement, the 1st word must be adjusted,
                                                    identifier  f  having been contra-declared on
                                                    S5aL6 or S1L13 or S3bL1 for example;
S3bL40: if d ≠ 2↑26 × 63 then go to                 Then identifier  f  may only have the significance
        S3bL41;                                     of a procedure identifier.                          ×
                                                    Identifier  f  has been found in the significance of
                                                    a formal parameter:;
        g : = if 16 × b < 0 then                    Cf. extract normally and prostat in tables 1 C      - ×
        2↑26 × 120 else 2↑26 × 98;                  and 1 D;
        go to S3bL47;                               S3bL40;
S3bL41: if d > 2↑29 then                                                                                ×
S3bL41a:wrong;                                      A procedure statement or function designator
                                                    invokes nonsense;
        if 16 × b > 0 then go to
        S3bL44;
        if st[g + 1] > 0 then go to
        S3bL44b;
S3bL41b:wrong;                                      A function designator or procedure statement having
                                                    actual parameters, invokes a function or procedure
                                                    having no formal parameters.
                                                    S3bL38;
S3bL42: if d = 2↑26 × 63 then go to                 Then identifier  f  is a formal parameter;          ×
        S3bL33;
        if 2 × d < 0 then
```

```
                                        comment
S3bL42a:wrong;                          A subcript has been attached to a simple variable;
        if 4 × d < 0 then go to         Then f is an array identifier;
        S3bL33;
        if 8 × d < 0 then go to         Then st[c] is replaced by a jump instruction;
        S3bL46;
S3bL42b:wrong;                          A subscript has been attached to a procedure
                                        identifier.
                                        S3bL37;
S3bL43: if 2 × d < 0 then go to         Then identifier  f  is either a simple variable
        S3bL33;                         or a formal parameter and st[c] is not changed;
        if 4 × d < 0 then
S3bL43a:wrong;                          An array identifier occurring within an expression
                                        is not followed by a subscript;
        if 8 × d < 0 then go to         Then  f  is a switch identifier or a label;
        S3bL46;                         Identifier  f  is a function or procedure name.
                                        The function designator or procedure statement
                                        has no actual parameters:
                                        S3bL41;
S3bL44: if st[g + 1] > 0 then
S3bL44a:wrong;                          A function designator or procedure statement having
                                        no actual parameters, invokes a function or procedure
                                        having formal parameters.
                                        S3bL41;
S3bL44b:e : = J0;                       Cf. table 1E;
        go to S3bL47;                   On address  c , a code instruction is stored which,
                                        in operation time, jumps to address  g  where the
                                        object programme of the function or procedure
                                        begins.
                                        S3bL39;
```

```
                                        comment
S3bL45: if b = d then go to S3bL46;     Then  f  is a label or switch identifier.
                                        Identifier  f  is a formal parameter:;
        g : = 2↑26 × 122;               Cf. jump in table 1D;                          ×
        if d = 2↑26 × 63 then go to
        S3bL47;                         Then  f  is indeed a formal parameter;         ×
S3bL45a:wrong;                          nonsense, referred to in a designational
                                        expression.
                                        S3bL42, S3bL43;
S3bL46: g : = 2↑23 + 2↑26 × 122;        Cf.jump in table 1D.                           ×
                                        S3bL40, S3bL44, S3bL45, S3bL48;
S3bL47: d : = e + g;
        go to S3bL32;                   for storing instruction or key main word.
                                        S3bL36;
S3bL48: g : = if 2 × b < 0
        then 2↑23 + 2↑26 × 109          Cf.Verify in table 1D and key main word of
        else 2↑23 × 89;                 constant parameter in table 3;                 ×
        go to S3bL47
        end S3b;
```

```
      begin                                  comment
                                             Compound statement S3c.
                                             Colon goes to here from input;
S3cL1: if(D or 2↑24) ≠ 0 then go to
       S3cL2;                                Then colon declares the label preceding it  ×
                                             in the text.
                                             Otherwise pattern  D  contains the type
                                             indication of an array declaration, colon being the
                                             separation symbol between a lower and upper bound:;
       f : = 331;                            Cf. colon in table 1B;
       go to S1L1;                           S3cL1;
S3cL2: SOh;                                  Cf.S3L2;
S3cL3: if g > 0 then go to S3cL7;            Then label is an integer
                                             (compare procedure SO1);
       if e = 0 then
S3cL3a:wrong;                                Label has been omitted;
S3cL4: f : = st[S];                          Cf. S4L23.
                                             S3cL8;
S3cL5: e : = P + R + 2↑23 × 127;             Cf. label in table 2;                       ×
       SOe(f);                               Thus declaration of label is listed;
S3cL6: SO (q + R + 2↑23 + 2↑26×119);         Cf. restore in table 1D;                    ×
       go to S1L28;                          S3cL3;
S3cL7: if e < 0 or 2↑24 < = e then                                                      ×
S3cL7a:wrong;                                Cf. table 5;
S3cL8: f : = e + 2↑24 × 63;                  being the internal value of constant label  f;  ×
       go to S3cL5
       end S3c;
```

```
                                        comment
      begin                             Compound statement S4.
                                        After reading an identifier  f, procedure input
                                        goes to here.
S4L1: if D < 0 then go to S4L22;        Then identifier  f  must be looked for in the
                                        list I.
                                        Identifier  f  must be declared or specified
                                        (cf. table 2):;
S4L2: if 2 × D < 0 then go to S4L9;     Then identifier  f  is declared a simple variable;
S4L3: if 4 × D < 0 then go to S4L11;    array identifier;
S4L4: if 8 × D < 0 then go to S4L37;    switch identifier;
S4L5: if 16 × D < 0 then go to S4L24;   procedure identifier;                          ×
S4L6: if (D or 2↑23) ≠ 0                Then f is either a value parameter, or is to be specified.
                    then go to S4L32;   Identifier  f  is a formal parameter to be listed in I:;
S4L7: P := P - 1;
      e := st[P];
      SO(D); SO(e);                     Then st[P - 2] = D, and st[P - 1] = -2^13 × rank of
                                        procedure (cf. S4L28);
S4L8: e := q + 2↑26 × 63;                                                              ×
      q := q - 2;
      go to S4L19;                      Relative addresses q + 3 and q + 2 are reserved for
                                        the main - and by-word of the parameter key.
                                        S4L2;
S4L9: if 8 × D < 0 then go to S4L18;    Then variable is not own.
                                        Variable is own:;
S4L10: SOi;                             Cf. S4L24;
      go to S4L15;                      S4L3;
S4L11: a := st[S - 1];
S4L12: if 8 × D < 0 then go to S4L16;   Then array is not own.
                                        Array is own:;
```

```
                                                    comment
S4L13: if c ≠ 0 then go to S4L15;                   Then  f  is not the 1st identifier of the list.
                                                    1st identifier of the list:;
S4L14: SOi;                                         Cf. S4L24;
       st[S - 1] : = P;                             Then st [ S - 1 ] is no longer = 0.
                                                    Compound S6a will insert pre-value [a] of a = 1st array
                                                    of declaration (cf. explanation)
                                                    on address P.
                                                    S4L10, S4L13;
S4L15: e : = P + D + 2129;                          Then the bit e3 of the internal equivalent  = 1,    ×
                                                    as it is in the case of a variable or array being
                                                    not own;
       SO(0);                                       A place for the simple variable or the pre-value of
                                                    the array is reserved in the object programme;
       go to S4L20;                                 S4L12;
S4L16: if c ≠ 0 then go to S4L18;                   Then  f  is not the first identifier of the list.
                                                    1st identifier of the list:;
S4L17: SOh;                                         Thus the space of own variables and - arrays and of
                                                    the object programmes of procedures and switches,
                                                    which eventually precede the non-own array declaration,
                                                    is bridged by inserting a pass instruction in the
                                                    dynamic introduction of the block;
       st[S - 1]: = q;                              The relative address  q  is reserved for the
                                                    pre-value [a] (cf. S4L14), that is an internal
                                                    (non-declared) variable of the object programme.
                                                    S4L9, S4L16;
S4L18: e : = q + D; q : = q - 1;                    Thus internal equivalent  e  of identifier  f
                                                    contains the address reserved.
                                                    S4L8;
S4L19: e : = e + R;                                 cf. S4L26.
                                                    S4L15;
```

```
                                        comment
S4L20: T1 : = T;
       T2 : = st[S - 3];                That is the address T' mentioned in compound S3a;
       S0e(f);                          Thus declaration is listed in I;
       S0f;
       if d > 0 then go to S3bL33a;     Then identifier  f  is defined twice in the same
                                        block or procedure heading.
                                        S4L36;
S4L21: T2 : = Q00;                      Cf. table 1E;                                    +
       go to S1L29;                     S4L1;
S4L22: S0f;                             Identifier  f  is looked for on addresses T1 + 2,
                                        T1 + 4, ... T2, as explained in S0f;
S4L23: st[S - 1] : = e; st[S]: = f;
       go to input;                     Because of the possible necessity to make a
                                        contra-declaration, identifier  f  remains available
                                        on address  S, until the next delimiter is stored
                                        there in the list L.
                                        S4L5;
S4L24: S0i;                             As the object programme of the procedure which is
                                        going to be translated now, is to be passed by the
                                        dynamic introduction of the block, a location is
                                        reserved for the pass instruction needed, unless this
                                        reservation has already been made earlier on
                                        S4L10, S4L14, S4L24 or S4L37;
S4L25: e : = P + R + D;                 Thus the address  P  where the procedure has its
                                        object programme beginning, is contained in the
                                        internal equivalent  e  of procedure identifier  f;
S4L26: R : = R + 2↑13;                  R  is cleared in compound entry, and decreased on
                                        S8dL3.  r = 2^-13 x R  is the rank of the procedure,
                                        r - 1  is the rank of the procedure identifier;
```

```
                                    comment
S4L27: SO(X);                       Cf. table 1E;                                  +
S4L28: SO(-R);                      The patterns of eventual formal parameters are
                                    inserted between instruction X and constant -R so
                                    that the latter must be shifted then (cf.S4L7);
S4L29: st[S - 1]: = q;              Cf. procedure in table 1B.
       q : = Q0 - 1 ;               S4L39;                                         + x
       d : = 327;
S4L30: SOc(P);
       st[S - 1]: = T;
       SOc(d);
       SOe(f);                      Cf. S4L20;
S4L31: go to S3aL4;                 For translating a procedure, there has been listed
                                    in L:
                                    st[S - 5] = value q' of q which was present when
                                    declarator procedure was read,
                                    st[S - 4] = 2 + address P' where instruction X has
                                    been stored,
                                    st[S - 3] = address T' where procedure identifier f
                                    has been listed in I,
                                    st[S - 2] = value 327 of opening symbol procedure,
                                    st[S - 1] = 0.
                                    to be compared with the information listed by
                                    compound S3a.
                                    S4L6;
S4L32: e : = P - st[S - 4];         being the number of the formal parameters
                                    (cf.P' in S4L31);
       T2 : = R + e + e;            On that address the 1st parameter identifier is
                                    listed in I;
       SOf;                         Thus identifier f is looked up in parameter list;
```

```
                                    comment
      if d < 0 then
S4L33: wrong;                       Then specified identifier does not occur in the
                                    parameter list of the procedure;
S4L34: e : = P - 1 + (T - c)÷2;     On that address the pattern of the parameter to be
                                    specified, is listed in the object programme;

S4L35: st[e] : = st[e] or D;
S4L36: go to S4L21;                 S4L4;
S4L37: SOi;                         Cf. S4L24;
S4L38: D : = 2↑23 × 1023;
       T1 : = T;                    Cf. S3bL 3 and 4. The expressions of the switch
                                    list must be translated now;
       q : = q - 1;                 This is compensated by S8bL9.
                                    As there is supposed that the declarations of all
                                    local variables and arrays are precedent to those of
                                    switches and procedures, q + 1 is the lowest address,
                                    occupied by a local variable (namely the internal
                                    variable which is used by the adjust and restore
                                    instructions) the switch list may contain deliberate
                                    statements (jumping or not) as its elements;
       SOm(0)                       Within the list L, this 0 will be preceded by the
                                    pass instructions leading to the object programmes
                                    of the switch list elements, until the list of
                                    these pass instructions can be stored in the object
                                    programme of the switch (cf. S8bL7);

S4L39: d : = 328;
       go to S4L30;                 For translating a switch, there is to be listed now
                                    in L:
                                    st[S - 4] = address where the switch list element to
                                    be read now has its object programme beginning,
```

```
                comment
st[S - 3] = address where switch identifier is
listed in I, the internal equivalent being stored
in I  on  S8bL10,
st[S - 2] = value 328 of opening symbol switch,
st[S - 1] = 0

end S4;
```

```
                                    comment
      begin                         Compound statement S4a.
                                    After reading a constant  f, input goes to here
                                    with  f  and  g = 2^23 x 0 000000t01 in which the bit
                                    t  indicates the representation of  f: t = 1 → f is
                                    real, 0 → integral or boolean;

S4aL1: if D > 0 then
S4aL1a:wrong;                       Then a constant occurs within a list of identifiers
                                    to be declared;

S4aL2: st[S - 1] : = f;
       go to input;                 The delimiter which is subsequent to the constant
                                    is read

       end S4a;
```

```
                                    comment
     begin                          Compound statement S5.
                                    Pre-action of the opening symbol  (;
S5L1: S0h;                          Cf. S3L2;
     if D < 0 then go to S5L3;      Then either a function designator or a procedure
                                    statement or an expression enclosed within
                                    parentheses is going to be translated.
                                    A formal parameter list is beginning.
                                    Procedure S0h has assigned the value of opening
                                    symbol procedure (cf. table 1B) to variable d;
     if d ≠ 327 then
S5L1a:wrong;                        Then (occurs in an identifier list of a block
                                    head;
                                    S8dL8;
S5L2: D : = 2↑23 × 30;              Cf. table 2;                                    ×
     go to S3aL4;                   The parentheses of a formal parameter part are not
                                    listed in L.
                                    S5L1;
S5L3: if g > 0 then
S5L3a:wrong;                        Then  (  is preceded by a constant;
S5L4: if Saccent < S then S0d;      Compare this with S1L7, where the operator st[S - 2]
                                    which is on the point of being translated, has
                                    already been listed in L;
S5L5: Saccent : = 8191;             as happens too on S6aL11;
     f : = 320;                     Cf.  (  in table 1B;
     if e = 0 then go to S3L5;      Then an expression enclosed within parentheses is
                                    beginning in the text.
                                    function designator or procedure statement:;
S5L6: S0n(2↑23 × 63);               Thus identifier  f  is contra-declared according    ×
                                    to p = 0 0001111111, which constant is listed in
                                    table 2A together with an explanation;
```

```
S5L7: SOm(0); SOm(0);                    comment
                                         The keys of the actual parameters will be listed
                                         in L, until all actual parameters will have been
                                         translated (cf. S5aL17);

S5L8: SOc(P);
      SO(0);
      SOc(f);                            S5aL15;
S5L9: st[S - 3] ; = P;
      mark : = 1;                        Cf. table 4C;
      go to S1L28;                       For translating a function designator or procedure
                                         statement, having actual parameters,
                                         there has been listed in L:
                                         st[S - 4] = address where to store the key address of
                                         the function designator or procedure statement
                                         (cf. S5aL23).
                                         st[S - 3] = address where the object programme (it
                                         may be empty) of the next actual parameter begins,
                                         st[S - 2] = value 320 of  (,
                                         st[S - 1] = 0

     end S5;
```

```
                                    comment
    begin                           Compound statement S5a.
                                    After-actions of the opening symbol (.
                                    Delimiter f read last is either a comma or ).
                                    On S1L1 the value of st[S - 3], as left by compound
                                    S5, has already been assigned to variable c.
                                    Progressive:
                                    Delimiter f is preceded in the text by p which
                                    is either a string or a trivial expression (identifier
                                    or constant).
                                    S1L6;
S5aL1: if c ≠ 0 then go to S5aL7;   Then p is an actual parameter.
                                    p, though enclosed within parentheses, is no
                                    parameter;
S5aL2: SOk;                         Thus the object programme is equipped with filling the
                                    accumulator.
                                    Regressive:
                                    Delimiter f is preceded in the text by a non-trivial
                                    expression p.
                                    S1L21;
S5aL3: if c ≠ 0 then go to S5aL24;  Then p is an actual parameter.
                                    p is no actual parameter:;
       if f = 321 then go to S5aL5; Then expression p is enclosed within brackets
                                    (cf. S6L12).
                                    S5aL23;
S5aL4: if f ≠ 320 then
S5aL4a:wrong;                       Actual parameter, or expression intended to be
                                    enclosed within parentheses (or brackets), is
                                    followed by a wrong delimiter.
                                    S5aL3, S6aL26, S6aL42;
```

```
                                                    comment
S5aL5: Saccent : = S : = S - 2;
S5aL6: go to S1L27;                                 Delimiter st[S-2] is regressive, for it is precedent
                                                    to parentheses or brackets in the text. If its rank
                                                    should be not greater than that of the delimiter to
                                                    be read next regressivity is detected on S1L5.
                                                    S5aL1;
S5aL7: if g > 0 then go to S5aL10;                  Then  p  is a constant, e, and g = 0 000000t01...0,
                                                    bit  t  indicating the representation of  e;
       if c > 0 then go to S5aL8;                   Then  p  is an identifier, st [S] (cf. S4L23),
                                                    c being the address listed in L on S5L8.
                                                    p  is a string, c  being the complement of the
                                                    mentioned address (cf. compound S5b):;

       d : = -c;  e : = P ;
       go to S5aL14;                                Thus the object programme of the string occupies the
                                                    addresses  d, d + 1, ... e - 1.
                                                    d, e  becomes the string key (cf. table 3).
                                                    S5aL7;
S5aL8:  c : = st [S] + 2↑32;                        As the parameter may be a label or a procedure- or  x
                                                    switch identifier declared later in the text, the
                                                    parameter key may (and possibly can) not yet be
                                                    formed. Thus a contra-declaration of identifier st [S]
                                                    will be made according to p = 0 000000000 which
                                                    constant is listed in table 2A together with a
                                                    general explanation;

S5aL9:  d : = T;
       go to S5aL13;                                The contra-declaration is to point to the address  x
                                                    where the key main word will be inserted in the object
                                                    programme. As  x  is still unknown in this stage of
                                                    the translation, the address  d  where contra-identifier
```

comment

c will be listed in I, is stored in L as a - preliminary key main word to be used on S5aL20 for storing the internal equivalent of c.
S5aL7;

S5aL10: d : = g + 2↑26 × 63; which is similar to the internal equivalent of a simple variable (cf. table 2); ×

S5aL11: if e < 0 or 2↑24 ≤ e then go to S5aL14; Then constant e is either no integer or anyhow unsuitable for being used as a label. Thus no contra-declaration is made. × Otherwise the constant parameter e will be contra-declared according to p = $\overline{1\ 000000000}$ which constant is listed in table 2A together with an explanation:;

S5aL12: c : = e + 2↑24 × 63 + 2↑32; which is a contra-identifier;
d : = d + T; Again (cf. S5aL9) the preliminary key main word points to an address in I.
S5aL9;

S5aL13: SOe(c); Thus contra-identifier c is listed in I.
On S5aL20 its internal equivalent is stored.
S5aL7, S5aL11, S5aL26;

S5aL14: if f ≠ 330 then go to S5aL16; Then delimiter f is no comma, thus the actual parameter part is closing in the text.
f is a comma (cf. table 1B):;

S5aL15: SOm(d); SOm(e); Then there is in L:
go to S5L9; st[SO] = by-word e, and
st[SO + 1] = main word d of parameter key, and
the next actual parameter is read.
S5aL14;

```
                                        comment
S5aL16: SO(O);                          Then, in the object programme, st[P - 1] = 0,
                                        st[P] becoming the by-word of the parameter which
                                        is the last element of the parameter list.
                                        Transport cycle:
                                        S5aL22;
S5aL17: if d < 0 then go to S5aL21;     Then parameter is a non-trivial expression and the
                                        key is ready (cf. S5aL25);
S5aL18: g : = P + 1;                    The key main word is to be stored on address g;
        c : = 8191 or d;                Then  c  is either = 0, or the address where the
                                        required contra-declaration is to be listed in I,
                                        or the address where the object programme of the
                                        string begins;
        d : = d - c;
S5aL19: if d = 0 then go to S5aL20;     Then parameter is either a single identifier or
                                        a string.
                                        Parameter is a constant:;
        d : = d + P;                    Then the key of the parameter looks as follows:
                                        st[P]= constant  e,
                                        st[P + 1] = d = P + 0 111111t01 0...0;
        g : = g + 2132;                 which = P + 1 + 2^32. If c ≠ 0, then constant  e  ×
                                        may occur as a label (cf. table 2A).
                                        S5aL19;
S5aL20: if c > T then st[c - 1]: = g;   which is the internal equivalent of the contra-
                                        identifier stored in I on S5aL13. It refers to the
                                        main word of the parameter key which is to be formed
                                        or modified, when the translator will have arrived
                                        on S3bL23.
                                        S5aL17;
```

```
                                        comment
S5aL21: SO(e); SO(d);                   Thus there has been added to the object programme:
                                        st[P - 2] = by-word  e, and
                                        st[P - 1] = main word  d  of the parameter key;
S5aL22: e : = st[SO]; d : = st[SO+1];   Thus next parameter key is extracted from L;
        SO : = SO + 2;
        if d ≠ 0 then go to S5aL17;     Then the next key is transported.
                                        All keys have been stored in the object programme;
S5aL23: S : = S - 2; SOa;               Then  d  is the address denoted with st[S - 4]
                                        on S5L9;
        st[d] : = P;                    which is the key address of the function designator
                                        or procedure statement;
        go to S5aL4;                    S5aL3;
S5aL24: if mark ≠ 0 then go to S5aL27;  Then mark = 1, the parameter having the form i[E],
                                        in which identifier  i = st[S].
                                        i  is expected to be either an array- or switch
                                        identifier.
                                        Parameter is a non-trivial expression differing
                                        from i[E]:;
        SO(return);                     cf. table 1E. In the object programme of a      +
                                        parameter i[E] which is a subscripted variable or
                                        switch designator, the last word = 0 instead of return.
                                        S5aL27;
S5aL25: e : = c + EO;                   cf. table 1E;                                   +
        d : = 2↑23 × 1017;              d, e  is the key of an actual parameter which is ×
                                        a non-trivial expression; (cf. table 3);
S5aL26: go to S5aL14;                   S5aL24;
S5aL27: P : = P - 1;                    Then st [P] is either an ar2 instruction or 0
                                        (cf. S6aL61);
```

```
                                        comment
S0s;                                    The mentioned identifier  i  is contra-declared
                                        because the ar2 instruction might, and a zero must
                                        be replaced later by a jump instruction.
                                        A zero is added to the parameter's object programme;
go to S5aL25
end S5a;
```

```
                                        comment
      begin                             Compound S5b.
                                        Action of delimiter lsq (cf. table 1B);
S5bL1: S0a;                             Then d = delimiter st[S - 2], the parenthesis
                                        having the value 320;
      if d ≠ 320 or c = 0               Otherwise the string beginning in the text is an
      then go to S5bL2;                 actual parameter;
      st[S - 3] : = - c;                Thus the address  P  listed in L on S5L8 is replaced
                                        by its complement;
      go to input1;                     Then the string is read. For storing the successive
                                        words, procedure S0 is recommended, because it also
                                        pays attention to the position of the list  L.
                                        After skipping delimiter rsq, input1 goes to S1L28;
S5bL2: wrong;                           This string is no actual parameter thus perhaps a
                                        piece of code programme to be included in the object
                                        programme?
      end S5b;
```

```
      begin

S6L1: f : = 321;
      if D < 0 then go to S6L10;

S6L2: S0a;

      if e = 0 then
S6L2a: wrong;
S6L3: D : = D + 2↑32;

S6L4: if D or 2↑29 ≠ 0 then go to
      S6L6;
S6L5: e : = P;

      go to S6L7;
S6L6: e : = q;

      T1 : = c;
```

comment
Compound statement S6.
Pre-action of the opening symbol [.
cf. [in table 1B;
Then a subscript list is beginning in the text.
- bound pair list:;
Then the following assignments are performed:
c = value, variable T had, when the 1st declarator of the block was read (cf. S3aL5),
d = value 322 of the opening symbol begin,
e = address, reserved for the pre-value [a] of the 1st array, called a in the explanations (cf. S4L14 and S4L16);

Then a list of array identifiers has been omitted;
for D must be negative during the translation of the expressions of the bound pairs. Then the tests on S6L1 and S4L1 succeed;
Then the arrays are not own.
Arrays are own:;
which = 1 + address where pre-value [c] of c, the last array of the list, is to be stored later (cf. S6aL41);
S6L4;
That address is reserved for the internal variable u.
Thus address e + 1 is reserved for pre-value [c] of c, the last array of the list;
for, within the bounds, there only occur non-local variables.
S6L5;

```
                                        comment
S6L7: SOc(e);
S6L8: e : = e + R + 2↑23 - 2 +          cf. ar1 in table 1D;
           2↑26 × 126;                                                  ×
      SOe(2↑24 × 62);                   In the case of an own declaration, the internal   ×
                                        equivalent of the factor identifier 2^24 × 62 is not
                                        e and will be inserted later on S6aL38;
S6L9: go to S3L3;                       Then, for translating a bound pair list, there is
                                        listed in L:
                                        st[S - 5] = address reserved for the pre-value [a] of
                                        a = 1st array of the list mentioned in the
                                        explanations,
                                        st[S - 4] = ∓ 1 + address reserved for the pre-value
                                        [c] of c = last array of the list,
                                        st[S - 3] = -1 + number of bound pairs already
                                        translated,
                                        st[S - 2] = value 321 of [ ,
                                        st[S - 1] = 0.
                                        S6L2;
S6L10: SOh;                             for a procedure statement with actual parameters can
                                        be the 1st statement in the compound tail of a block
                                        (cf. S3L2);
S6L11: if g ≠ 0 then go to S6L15;       Then [ is preceded by an array identifier;
S6L12: if e = 0 then go to S5L4;        Then there is beginning an expression enclosed
                                        within brackets, which is no subscript.
                                        [ is preceded by either a formal parameter or a switch
                                        identifier:;
S6L13: if e or (2↑32 + 2↑23) ≠ 0 then   cf. ar2 in table 1D.
       e : = 2↑26 × (63 - 125);         Then [ is not preceded by a formal parameter. Thus   ×
                                        it is preceded by a switch identifier whose declaration
                                        may, of course, occur later in the text;
```

```
                                        comment
S6L14: st[S - 1] : = e + 2↑26 ×         That is either the ar1 instruction referring to a
                     (126 - 63);        formal parameter, or a positive and harmless      ×
                                        constant;
       go to S6L18;                     S6L11;
S6L15: if g > 0 then
S6L15a:wrong;                           Then [ is preceded by a number;
S6L16: st[S - 1] : = g;                 which is the ar1 instruction listed in I on S6L8 and
                                        referring to the 1st factor of the array declaration;

S6L17: e : = U + 2↑31;                  Then bit e1 = 1 as it is in the case that e is the
                                        internal equivalent of a formal parameter.
                                        S6L14;
S6L18: S : = S + 2;
       if S + 1 > T then S0g;           as happens in procedure S0c;
       st[S - 1] : = e + 2↑26 ×
                     (125 - 63);                                                          ×
       S0c (- mark);                    as is indicated in table 4C;
       st[S - 1] : = 0;
S6L19: go to S3L5;                      Then, for translating a subscript list, there is
                                        listed in L:
                                        st[S - 7] = an ar1 instruction or a positive constant,
                                        st[S - 6] = the array- or switch identifier or the
                                        formal parameter, preceding [ in the text,
                                        st[S - 5] = an ar2 instruction of 0,
                                        st[S - 4] = minus the value of mark which was
                                        present when [ was read,
```

```
                    comment
st[S - 3] = - 1 + number of subscripts already
translated,
st[S - 2] = value 321 of [ ,
st[S - 1] = 0

end S6;
```

```
                                    comment
    begin                           Compound statement S6a.
                                    After-actions of the opening symbol [ .
                                    Delimiter f read last is either a comma or a colon
                                    or ] . On S1L1 (or S1L18) the value of st[S - 3] as left
                                    by compound S6, has already been assigned to variable c.
                                    Progressive:
                                    In the text, delimiter f is preceded by a trivial
                                    expression p (a constant or identifier).
                                    S6L1;
S6aL1: d := st[S - 4];              Compare S6L9 with S6L19;
S6aL2: if d ≤ 0 then go to S6aL43;  Then p is a subscript.
                                    p is a bound:;
S6aL3: if D or 2↑29 = 0 then go to  Then declaration is own.
       S6aL27;                      Declaration is not own:;
S6aL4: S0k;                         Thus p is translated.
                                    Regressive:
                                    expression p is not trivial and is already
                                    translated.
                                    S1L21;
S6aL5: d := st[S - 4];              cf. S6aL1;
S6aL6: if d ≤ 0 then go to S6aL53;  Then p is a subscript.
                                    p is a bound:;
S6aL7: if D or 2↑29 = 0 then                                              ×
S6aL7a:wrong;                       Please only constant bounds in an own array
                                    declarations;
S6aL8: if c ≠ 0 then d := d + 1;    Thus, in the case of the 1st bound pair, d is
                                    the address of variable u, otherwise d is the
                                    address of variable v = [c], as is indicated in
                                    the explanations;
```

```
                                                    comment
S6aL9: if  f ≠ 331 then go to S6aL12;               Then delimiter  f  is no colon.
                                                    colon:;
S6aL10: SO(d+R+2↑23+2↑26×117);                      cf. store accu in table 1D.                    ×
                                                    Thus  u : = accu or  v : = accu is translated.
                                                    entry, S3bL5, S7aL9, S7aL17, S6aL19;

S6aL11: Saccent : = 8191;
        go to S1L27;                                As long as S' has the value 8191, the tests on
                                                    S1L7, S5L4 and S6aL44 cannot succeed.
                                                    S6aL9;
S6aL12: if c = 0 then q : = q - 1;                  the latter being the same as q : = d - 1.
                                                    Then  q  is the address to be reserved for the
                                                    variable H_k, the value of which is the number of
                                                    array elements;
S6aL13: SO(d+R+2↑23+2↑26×74);                       cf.  -  in table 1A.                           ×
                                                    Thus accu : = accu - u or accu : = accu - v is
                                                    translated;
S6aL14: SO(q+R+2↑23+2↑26×115);                      cf. store factor in table 1B;                  ×
S6aL15: if c = 0 then e : = 0 else
        e : = c + 2;                                else e : = d - q  may be written instead;
S6aL16: SO(e);                                      Thus the constant 0 or k - i + 2 (i < k, cf.
                                                    explanation) is subsequent to the store factor
                                                    instruction;
S6aL17: q : = q - 1;                                That address is reserved for the variable to be
                                                    introduced next which is possibly another factor
                                                    h_{i-1}.
                                                    S6aL36, S6aL58;
S6aL18: st[S - 3]: = c : = c + 1;                   Thus the number of bound pairs or subscripts is
                                                    counted;
S6aL19: if  f = 330 then go to S6aL11;              Then  f  is a comma;
```

```
                                                    comment
        if f ≠ 321 then
S6aL19a:wrong;                                      Then a subscript, or a bound of an array declaration,
                                                    is not followed by the required comma, ], or colon;
S6aL20: D : = D + 2↑32;                             which compensates for S6L3;                          ×
S6aL21: S : = S - 2;
S6aL22: if  D  or 2↑29 = 0 then go to
        S6aL37;                                     for own;                                             ×
S6aL23: S0a;                                        Then is (cf. S6L9):
                                                    c = address reserved for variable [a],
                                                    d = address reserved for  u;
S6aL24: S0(c+R+2↑23+2↑26×114);                      cf. store pre-value in table 1D;                     ×
S6aL25: S0(d - c);                                  In the object programme, the store pre-value
                                                    instruction is followed by the constant which is the
                                                    difference (address of  u  minus that of [a] );
S6aL26: go to S5aL5;                                The brackets are exhausted.
                                                    S6aL3;
S6aL27: if g = 0 then go to S6aL7a;                 Then a variable bound occurs within a declaration
                                                    of own arrays;
S6aL28: if g + 2↑25 × 127 < 0 then go               Then the bound has not the integer representation;
        to S6aL7a;
S6aL29: if  f ≠ 331 then go to S6aL32;
S6aL30: if c ≠ 0 then v : = e
        else u : = e;
S6aL31: go to S1L28                                 S6aL29;
S6aL32: if c ≠ 0 then e : = e - v
        else e : = e - u;
S6aL33: if e < 0 then
S6aL33a:wrong;                                      Then lower bound is greater than upper bound;
        e : = e + 1;
```

```
                                                comment
S6aL34: S0m(e);                                 In the store, the calculated constants must appear
                                                in the same order as have the factor variables of the
                                                arrays being not own. Storing in L through procedure
                                                S0m is a means of reversing the order;

S6aL35: if c = 0 then go to S6aL36;
        st[S0 + c]: = st[S0 + c] × e;           which is the next value of H_k;
        u : = u × e + v;                        which is the next value of u.
                                                S6aL35;
S6aL36: go to S6aL18;                           S6aL22, S6aL37;
S6aL37: g : = st[S0]; S0(g);
        S0 : = S0 + 1;
        c : = c - 1;
        if c ≠ 0 then go to S6aL37;             Thus the constants h_1, ... h_k-1, and H_k are listed
                                                in the object programme,
                                                g being = H_k at the end;
S6aL38: st[T+1]: = P+2↑23+2↑26×126-2;           which is the correction announced on S6L8;          ×
S6aL39: S0(u);                                  Constant u is stored;
S6aL40: S0a;                                    cf. S6aL23.
                                                Addresses c and d-1 are reserved for the first
                                                and last pre-value constants.
                                                S6aL41;

S6aL41: st[c]: = P - u; P : = P = g;
        c : = c + 1;
        if c ≠ d then go to S6aL41;             Thus space for own arrays is reserved in object
                                                programme;

S6aL42: if P>S0-2 then S0g;
        go to S5aL5;                            S6aL2;
S6aL43: if c ≠ 0 then go to S6aL45;             Then the identifier or constant p to be translated
                                                is not the first subscript of the list.
                                                First subscript:;
```

```
                                                comment
S6aL44: if Saccent + 2 < S then S0d;        as happens also on S1L7;
        S0k;                                Thus 1st subscript is translated;
        go to S6aL54;                       S6aL43;
S6aL45: P : = P - 1;                        Then st[P] = instruction partres, stored at the
                                            previous action of this compound S6a on S6aL57;
S6aL46: if g ≠ 0 then go to S6aL50;         Then  g  indicates the representation of  e,
                                            e  being a constant subscript
S6aL47: if e < 0 then go to S6aL52;         Then subscript  p  is a procedure identifier namely
                                            no simple variable and no formal parameter.
                                            Simple variable or formal parameter;
S6aL48: e : = e + 2↑26 × (72 - 63);         cf. + in table 1A;                                  ×
S6aL49: go to S6aL51;                       S6aL46;
S6aL50: S0(g + 2↑26 × 72);                  cf. S6aL48.                                         ×
                                            S6aL49;
S6aL51: S0(e);
        go to S6aL54;                       not: to 53.
                                            S6aL47;
S6aL52: P : = P + 1;                        Thus instruction partres  remains in the object
                                            programme;
        S0p;                                Thus a contra-declaration of function name  p  is made.
                                            The test on S6aL53 succeeds.
                                            S6aL6;
S6aL53: if c ≠ 0 then                       cf. + in table 1A. This instruction
        S0(2↑23 × 3 + 2↑26 × 72);           accu : = accu + (partial result) corresponds to the  ×
                                            instruction partres, added to the object programme
                                            during the previous action of this compound S6a on
                                            S6aL57.
                                            S6aL44, S6aL51;
S6aL54: if f=321 then go to S6aL59;         cf. ] in table 1B. Then the last subscript has been
                                            translated.
```

```
                                        comment
                                        Subscript list is not yet exhausted:;
S6aL55: d : = st[S - 7];                That is either an ar1 instruction referring to an
                                        array identifier or formal parameter, or positive;
        if d > 0 then
S6aL55a:wrong;                          Then 2 or more subscripts are attached to an identifier
                                        which is no array identifier and no formal parameter;
S6aL56: if d - 2↑23 - 2↑26×126 < 0                                                          ×
        then SO(d) else c : = d - c;
        SO(c);                          Thus the ar1 instruction just stored either refers
                                        itself to the factor h_i (i < k) required, or it
                                        refers to the key of a formal parameter which refers
                                        to the factor h_k-1 of the array represented by the
                                        parameter, while ar1 is followed, in the object
                                        programme, by the constant  k - i - 1;
S6aL57: SO(partres);                    cf. table 1E                                        +
                                        This instruction partres corresponds to the
                                        instruction
                                        accu : = accu + (partial result)
                                        which will be added to the object programme during
                                        the next action of this compound (cf. S6aL53).
                                        However, often both instructions are dispensable;
S6aL58: go to S6aL18;                   S6aL54;
S6aL59: mark : = - d;                   Thus the value of mark, listed in L on S6L19, is
                                        restored;
S6aL60: Saccent : = S : = S - 6;        Compare this with S5aL5;
S6aL61: SO(st[S + 1]);                  Then st[P - 1]is the ar2 instruction or 0, mentioned
                                        on S6L19.
```

```
                comment
                st[S] is the identifier to which the subscripts
                are attached in the text;

go to S1L28
end S6a;
```

```
      begin

S7L1: SOh;
S7L2: st[S - 1] : = 0;

      SOc(0);
      st[S - 1] : = - P;
      f : = 324;
      go to S3L4;

      end S7;
```

comment
Compound statement S7.
Pre-action of the opening symbol for
cf. S3L2;
Thus an identifier or constant preceding opening symbol for is skipped;

Then, for translating a for statement, there is listed in L:
st[S - 5] = 0,
st[S - 4] = 0 to be replaced by the internal equivalent of the controlled variable v on S9L4,
st [S - 3] = minus address P' where the object programme of the for list element to be read next is to begin,
st [S - 2] = value 324 of the opening symbol for,
st [S - 1] = 0

```
        begin                    comment
                                 Compound statement S7a.
                                 After-actions of the opening symbol for .
                                 Delimiter f read last may be a separation symbol
                                 step, until, while, comma, or do, or the closing
                                 symbol of the for statement.
                                 Progressive:
                                 Expression p preceding delimiter f in the text
                                 is trivial (an identifier or constant).
                                 S1L6;
S7aL1: S0k;                      for translation of p.
                                 Regressive:
                                 Expression p is not trivial.
                                 S1L21;

S7aL2: S : = S - 2;
       S0a;                      Thus internal equivalent of controlled variable is
                                 assigned to variable d
                                 (cf. st [ S - 4 ] in compound S7);

       if d ≤ 0 then
S7aL2a:wrong;                    Then either controlled variable is no simple variable
                                 and no formal parameter,
                                 or even : = has been omitted;
S7aL3: if c < 0 then go to S7aL18; Then after-action of for with do has already taken
                                 place so that f is the closing symbol (compare
                                 st[S - 5] in S7aL16 with that in S7aL15 or S7L2);
S7aL4: S : = S + 2;              Thus previous value of S is restored;
       if f ≠ 324 then go to S7aL10; Then f is either comma or do (cf. 324 in table 1B);
S7aL5: if e < 0 then go to S7aL7; Then delimiter f is either step or while.
                                 Delimiter f = until:;
S7aL6: st[e] : = d+2↑26 ×(123-63); cf. for1 in table 1D;
```

```
                                        comment
        SO(for3);                       cf. table 1E;                                   +
        c : = 0;
        go to S7aL8;                    S7aL5;
S7aL7:  c : = P;
        SO (-e);                        Thus address where object programme of while- or
                                        step element begins, is retained in object programme
                                        itself on address  c;
        SO(d + 2↑26 × (117 - 63));      cf. store accu in table 1D.                     ×
                                        S7aL6, S7aL15;
S7aL8:  st[S - 3] : = c;
S7aL9:  go to S6aL11;                   st[S - 2] = for remains in L,  f  disappears.
                                        S7aL4;
S7aL10: if e > 0 then go to S7aL12;     Then value of  e  has been listed in  L  during
                                        previous action of this compound on S7aL7-8.
                                        It is a while element whose object programme is to be
                                        completed;
S7aL11: if e ≠ 0 then
        begin                           element is an expression
        SO(d + 2↑26 × (117 - 63));                                                      ×
        b : = for2;                     cf. table 1E                                    +
        end
        else b : = d + 2↑26 × (74-63);  cf. in table 1A. It is a step element           ×
        SO(b);
        go to S7aL14;                   Object programme of step- or expression element is
                                        ready.
                                        S7aL10;
S7aL12: b : = st [e];                   That is the address  c  of S7aL7. Element has the
                                        form:  F while G.
                                        S7aL13;
```

```
                                                    comment
S7aL13: st[e] : = st [e - 1]:
        e : = e - 1;
        if e ≠ b then go to S7aL13;          Thus object programme of expression F is shifted
                                             over one place;
        st [b] : = for2;                     cf. table 1E.
                                             Thus instruction for2 precedes object programme of F.
                                             S7aL11;
S7aL14: if f = 323 then go to S7aL16;        cf. do in table 1B;
        if f ≠ 330 then
S7aL14a:wrong;                               Then for statement contains wrong delimiter;
S7aL15: st[S - 5] : = P;                     That is the address where to insert a for instruction
                                             later (cf. S7aL16);
        SO(c);                               On address st[S - 5] the previous address where to
                                             insert a for instruction, is stored;
        c : = - P;
        go to S7aL8;                         Thus c is the complemented address where the object
                                             programme of the next for list element is to begin.
                                             S7aL14;
S7aL16: e : = P+2+2↑23+2↑26×124;             cf. for in table 1D;                                    ×
        SO(e);                               Thus last for instruction is stored;
        st[S - 5]: = - P;                    That is the complemented address where to store a
                                             pass instruction later (cf. S7aL18);
        SO(0);                               For the time being, 0 is inserted.
                                             S7aL17;
S7aL17: if c = 0 then go to S6aL11;          Then all for instructions have been inserted;
        b : = c;  c : = st [c];
        st[b] : = e;                         Thus next for instruction is inserted on address b;
        go to S7aL17;                        S7aL3;
```

```
                                        comment
S7aL18: SO(forO);                       cf. table 1E.                                   +
                                        Thus object programme of for statement is concluded
                                        by adding the word forO;
        st[-c]: = P + 2↑23 + 2↑26 × 121;Thus a bridging pass instruction (cf. table 1D) is
                                        inserted;
        go to S1L17;                    There variable S is again (cf. S7aL2) decreased
                                        with 2, and the delimiter preceding for in L, is
                                        going to after-act with delimiter f

        end S7a
```

```
      begin

S8L1: S0h;
      S0c(325);

S8L2: mark : = 2;
      Saccent : = 8191;
      go to S1L28
      end S8;
```

```
comment
Compound statement S8.
Pre-action of the opening symbol  go to;
cf. S3L2;
Then st [ S - 2 ] is the value 325 of  go to
(cf. table 1B)
S8bL6, S9L3;
cf. table 4C;
as happens also on S6aL11;
```

```
      begin                                  comment
                                             Compound statement S8a.
                                             After-actions of the opening symbol  go to .
                                             Regressive (cf. S8bL1):
                                             S1L21;

S8aL1: if mark = 0 then go to S8aL3;
       P : = P - 1;                          Progressive (cf. S8bL2):
                                             S1L6;
S8aL2: SC1;                                  S2aL32, S8aL1, S8bL11;
S8aL3: mark : = 0;
       go to S1L17;                          Delimiter st[S - 4] is going to after-act with
                                             delimiter  f
       end S8a;
```

```
                                    comment
    begin                           Compound statement S8b.
                                    After-action of the opening symbol  switch .
                                    f = delimiter read last is either the separation
                                    symbol comma or the closing symbol semicolon of the
                                    switch declaration.
                                    Regressive:
                                    The designational expression  p  proceding delimiter
                                    f  in the text, is not a single label.
                                    S1L21;
S8bL1: if mark = 0 then go to S8bL3; Then  p  contains more than a switch designator and
                                    has already been translated and contra-declared.
                                    p  is a switch designator i[E]. Translation of  E  is
                                    ready. st[P - 1] = 0  or an ar2 instruction
                                    (cf. S6aL61) which is to be replaced by a jump
                                    instruction later.
                                    Identifier  i  is available as st[S] and  g = 0;
       P : = P - 1;                 Progressive:
                                    p  is a label.
                                    S1L6;
S8bL2: SO1;                         Thus there is made a contra-declaration of the label
                                    or switch identifier, referring to address P - 1
                                    where a jump instruction will be inserted later
                                    (cf. S3bL39).
                                    S3bL1;
S8bL3: S : = S - 2; SOa;            Now  d  is the address where the designational
                                    expression preceding delimiter  f  in the text, has
                                    it object programme beginning (cf. S8bL6 and S4L39);
S8bL4: o ; = d + 2↑23 + 2↑26 × 121; which is the pass instruction referring to  d;
```

```
                                                comment
S8bL5: if f ≠ 330 then go to S8bL7;             Then  f  is a semicolon.
                                                f  is a comma:;
S8bL6: S : = S + 2;                             Thus previous value of  S  is restored;
       st[S - 4] : = P;
       SOm(c);                                  For the time being, pass instruction is listed in L;
       go to S8L2;                              for reading next switch list element.
                                                S8bL5;
S8bL7: d : = 0;                                 for counting the entries of the switch list i.e.
                                                pass instructions preliminarily listed in L.
                                                S8bL8;
S8bL8: d : = d + 1;
       SO(c); SO : = SO + 1;
       c : = st[SO - 1];
       if c ≠ 0 then go to S8bL8;               Then the next pass instruction is stored in the
                                                object programme.
                                                The list of pass instructions has been stored in the
                                                object programme:;
 S8bL9: q : = q + 1;                            cf. S4L38;
S8bL10: st[e - 1] : = P+R+2↑23×127;             Thus internal equivalent (table 2) of switch  ×
                                                identifier is listed in  I;
S8bL11: SO(q + R + 2↑23 - 1 + 2↑26×112);cf. switch in table 1D;
       SO(d);                                   Thus, in object programme, the switch instruction
                                                is followed by the number of entries;
       go to S8aL3;
       end S8b;
```

```
                                    comment
    begin                           Compound statement S8d.
                                    After-actions of the opening symbol procedure.
                                    Progressive:
                                    S1L6;
S8dL0: wrong;                       Procedure body is a dummy or a single identifier
                                    or constant.
                                    Regressive:
                                    S1L21;
S8dL1: if D > 0 then go to S8dL8;   Then body must still be read.
                                    Body has been translated:;
       if f ≠ 332 then
S8dL1a:wrong;                       Then procedure body is not followed by a semi-colon;
S8dL2: S : = S - 2; S0a;            Then c = q', d = P' + 2 and e = T' are the values
                                    mentioned on S4L31;
S8dL3: R : = R - 2↑13;              for compensating the action of S4L26;          ×
S8dL4: if (st[e - 1] or 2↑24) = 0 then  cf. table 1E.                              +
       S0(extract procedure);       Thus instruction extract procedure only appears in
                                    the object programme of a type procedure;
S8dL5: S0(Y);                       table 1E.                                      +
                                    Thus, in object programme of any procedure,
                                    instruction Y is the last word;
S8dL6: if st[d - 1] < 0 then        Thus, in object programme of a procedure having no
       st[d - 2] : = X1;            parameters, instruction X1 of table 1E is 1st word; +
S8dL7: e : = e - 2; go to S3bL12;   S8dL1;
S8dL8: if f = 332 then go to S8dL9; for semi-colon;
       if (D or 2↑23) = 0 then go to
       S5L2;                        for reading the next formal parameter;
       go to S1L28;                 for reading parameter to be next specified.
                                    S8dL8;
```

```
                                                    comment
S8dL9: T1 : = T; D : = 2↑23 × 543;      Table 2;                                    ×
       go to S6aL11
       end S8d;
```

```
                                        comment
    begin                               Compound statement S9.
                                        Pre-action of the opening symbol : =;

S9L1: if g ≠ 0 then
S9L1a:wrong;                            Then : = is preceded by a constant;
S9L2: SOh;                              as happens also on S3L2. The procedure performed the
                                        following assignments:
                                        d : = st[S - 2],  e : =  st [S - 1];
S9L3: if d = 328 then go to S8L2;       Then the delimiter listed last in L is switch
                                        (cf. S4L39);
S9L4: if d ≠ 324 then go to S9L5;       Otherwise the delimiter listed last in L is  for:;
      st[S - 4] : = e;                  as was announced in compound S7;
      go to S1L28;                      S9L4;
S9L5: if e < 0 then go to S9L11;        Then : = is preceded in the text by the identifier
                                        of a type procedure;
      if e ≠ 0 then go to S9L7;         Then either a simple variable or a formal parameter
                                        is precedent to :=
                                        A subscripted variable is precedent to : =  ;

      if (st[P - 1] or 2↑26 × 127) ≠                                              ×
      2↑26 × 125 then
S9L5a:wrong;                            Then, within an assignment statement, : = is not
                                        preceded by a (simple or subscripted) variable or
                                        formal parameter or identifier of a type procedure;

S9L6: e : = - 1;
      go to S9L9;                       S9L5;
S9L7: e : = e + 2↑26 × (117 - 63);      cf. store accu  in table 1D;                                ×
S9L8: if e - 2↑23 - 2↑26 × 117 > 0
      then go to S9L10;                 Then a simple variable is precedent to : =                ×
                                        Formal parameter;
```

```
        e : = e + 2↑26;

S9L9:   S0(e);

        e  : = extract address;
                    *
S9L10:  st[S - 1] : = e;

        f : = 323;
        go to S3L4;
S9L11:  f : = e + 2↑32; S0f;
        e : = (d or 2↑26-2↑13)+2↑13
        + 2↑26×113+3+Q0;
        if (d or 2↑24 + 2↑29) = 0
        then go to S9L10;
        go to S9L5a
        end S9;
```

comment

cf. store address in table 1D.
S9L6;
Then st [P - 1] is either a store address instruction or the constant -1;
cf. table 1E. +
S9L8, S9L11;
Thus either a store accu-or store procedure- or extract address instruction is listed in L;
cf. : = in table 1B;
S9L5;
Thus procedure identifier is again looked up; ×
cf. store procedure and Q0 in tables 1D and 1E; + ×
Then identifier signifies a type procedure; ×

```
                                        comment
        begin                           Compound statement S9a.
                                        After-actions of the opening symbol  : =
                                        On S1L1 or S1L18, the value of st [S - 3] has been
                                        assigned to variable  c.
                                        Progressive:
                                        The expression preceding  delimiter  f  in the text
                                        is a single identifier or constant  p.
                                        S1L6;
S9aL1: S0k;                             Thus  p  is translated.
                                        Regressive:
                                        p  has already been translated.
                                        S1L21;
S9aL2: S0(c);                           Thus st[P - 1] is the instruction listed in  L  on
                                        S9L10;
        go to S1L17;                    cf. S8aL3;
        end S9a;

input:
        begin
          :
        end
input1:
        begin

          :
        end

        end  translator
```